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M26wqsk status report
1994

WATER QUALITY STATUS REPORT

Kootenay (Kootenai) River Basin
British Columbia, Montana and Idaho

Prepared for:
The Kootenai River Network

Prepared by:
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January 1994

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Acknowledgements

Funding for this project was provided by the U.S. Environmental Protection Agency, the Bonneville Power Administration, Noranda Minerals and Champion International. The author would like to thank all of the members of the Kootenai River Network for their encouragement and suggestions; particularly helpful support was provided by the three water quality agency representatives: Les McDonald, BC Ministry of Environment; Brian Hoelscher, Idaho Department of Health and Welfare; and Gary Ingman, Montana Department of Health and Environmental Sciences. Gary also skillfully guided this project through the contracting hoops and was always available to offer input and feedback throughout the preparation of this report. Thanks to Jill Davies for facilitating, and providing detailed minutes of, the 1992 and 1993 KRN meetings. Report layout and word processing was done by Jan Novy of Helena, Montana.

Forward

At least three spellings exist for the river and watershed discussed in this report. "Kutenai" is the spelling often found in documents describing the Native American inhabitants of the watershed. The Canadian spelling is "Kootenay" compared to "Kootenai" in the United States. Since the majority of the watershed and the lake to which it drains are in Canada, the Kootenay spelling is used throughout this report.

Certain data, particularly basin or watershed surface areas and annual stream discharge rates, are presented as approximate rather then absolute values. This was found to be necessary because of conflicting values in various reports utilized during preparation of this document. For example, Bonde (1987) states that the drainage area for the Kootenay Basin at Nelson is 50,180 km^2 (19,300 mi^2), while Daley et al. (1981), reported it to be 45,584 km^2 (17,532 mi^2). Stream discharge data, particularly for tributaries to the river, also frequently varied from report to report, likely because of differences in the period of record examined by the authors.

Finally, it is important to recognize that this report only addresses the portion of the Kootenay River Basin above Kootenay Lake, which composes roughly 80% of the total basin. However, activities in this watershed that have influenced, or continue to influence, the lake are noted accordingly.

Table of Contents

Acknowledgements i

Forward ii

Executive Summary 1

Introduction 3

Description of the Kootenay River Network 3

Purpose of report 4

Description of the Kootenay River Basin 4

An overview of water quality protection statutes 11

An assessment of existing and potential effects to water resources 15

Hydroelectric facilities 15

Mining 22

Forest practices 32

Municipal wastes 38

Highways and railroads 38

Agriculture 40

Subbasin descriptions 41

Subbasin 1 41

Subbasin 2 44

Subbasin 3 45

Prioritization of water quality issues 47

Recommendations 50

Literature cited 54

List of Figures

Figure 1
Map of the Kootenay Basin 5

Figure 2
Portion of the Kootenay River Basin discussed in the report 7

Figure 3
Hydrograph of the Kootenay River below Libby Dam 19

Figure 4
Mean monthly flow, water temperature and relative photoperiod in the Kootenay River at Porthill, Idaho before and after the operation of Libby Dam 20

Figure 5
Recommended minimum discharge in the Kootenay River at Bonners Ferry to enhance white sturgeon spawning 21

Figure 6
Heavy metal concentrations in the Kootenay River below the St. Mary River 1973-1989 24

Figure 7
Orthophosphorus and ammonia concentrations in Cominco's effluent 1975-1979 26

Figure 8
Soluble reactive phosphorus concentrations in the Kootenay River (below the St. Mary River) vs. the Elk River 1968-1989 27

Figure 9
Soluble reactive phosphorus concentrations in the Kootenay River (below the St. Mary River) vs. the Elk River 1976-1989 28

Figure 10
Locations and relative sizes of coal mines in the Elk River Basin 30

Figure 11
Kootenay River subbasins 42

Executive Summary

The Kootenay River Basin is an international watershed. It is located primarily within the province of British Columbia, with smaller portions of the basin located within the states of Montana and Idaho. The basin is sparsely populated, mountainous and blessed with spectacular scenery. Principal industries are forest products, mining, hydropower production, recreation (tourism) and, to a lesser extent, agriculture. Fish species of special concern are the bull trout (*Salvelinus confluentus*) and the white sturgeon (*Acipenser transmontanus*), which are both presently being considered for listing as threatened or endangered species in the U.S. Approximately 90% of the land in the basin is government-owned or managed; i.e., National Forests in the U.S. and Crown Land in British Columbia. Differences exist regarding how these two categories of public land are administered, managed and allocated for development. Differences also exist among water quality standards or criteria in British Columbia, Montana and Idaho.

Water pollution impacts from the Cominco Mine and fertilizer plant at Kimberley, BC, which were quite severe in the 1960s and 1970s, have largely been controlled or eliminated. Abandoned hard rock mines are located throughout the U.S. portion of the basin, but their influences upon water quality are largely unknown. Two other large mining operations are ASARCO's copper and silver mine near Troy, MT and Noranda's proposed mine near Libby, MT. Suspended sediment problems originating from open-pit coal mines in the Elk River watershed were quite significant in the 1970s; improved waste treatment efforts have reduced these effects, although localized problems remain on some small tributaries.

Since 1968, Crestbrook Forest Industries' pulp mill at Skookumchuck has been the largest point source discharge to the Kootenay River. During the 1970s pollution from this mill significantly impacted fish populations and water-based

recreation. Pollution control efforts in the 1980s reduced this effect. Further upgrading of the mill's waste treatment facility, which is now underway, should continue to improve effluent quality. Monitoring for pollutants found in pulp mill wastewater is being conducted in Canada; similar monitoring should also be conducted in the U.S. The effects of logging and road building upon fish and other aquatic life remains largely undocumented, primarily because public agencies do not have sufficient funds or staff to conduct necessary instream monitoring.

The effects of domestic wastewater upon receiving streams has been minimized in recent years; for example, Cranbrook, the largest municipality in the basin, has not discharged its domestic wastes to surface waters since 1977. Since 1972, Libby Dam and its reservoir have influenced the water quality, fisheries and recreational value of the Kootenay River and Kootenay Lake to a greater degree than any other single facility or pollution source. The dam and reservoir remain the most conspicuous and persistent sources of water resource controversy in the basin.

Very little water quality monitoring occurred in the basin prior to the 1970s. Even today there are few active monitoring stations. Continued or expanded monitoring should occur at a minimum of four stations so water quality trends can be determined; i.e., the Kootenay River at Canal Flats, downstream of the St. Mary River, below Libby Dam and just upstream from Kootenay Lake.

Coordination among international, provincial, tribal and state agencies charged with water quality and other aquatic resource management needs to be improved, as does communication among industry, agency and citizen groups. The Kootenai River Network must continue and expand upon its informational and educational efforts to accomplish better understanding and management of water quality and other aquatic resources in the Kootenay River Basin.

Introduction

Description of the Kootenay River Network (KRN)

The KRN is composed of federal, state, tribal, provincial, industry and citizen group representatives that are interested in the chemical, physical and biological integrity of the Kootenay River Basin. Present objectives of the KRN include:

- providing a forum for the sharing of water resource information;
- identifying issues and concerns in the basin; and
- developing and implementing cooperative interstate and international water quality monitoring programs.

Since 1992, the KRN has met four times per year at various locations in the basin. Agencies or organizations in attendance have included:

- BC Ministry of Environment
- Cabinet Resource Group
- Champion International
- East Kootenay Environmental Society
- ID Dept. of Fish and Game
- ID Division of Environmental Quality
- Kootenai National Forest
- Kootenai Tribe of Idaho
- Kootenay Tribes of BC
- MT Dept. of Fish, Wildlife and Parks
- MT Dept. of Health and Environmental Sciences
- Noranda Minerals Corp.
- Panhandle National Forest

All persons interested in the future of water resources in the Kootenay River and its tributaries are welcome to attend the KRN's quarterly meetings. Information regarding the time and place of meetings can be obtained from:

Gary Ingman
MT Dept. of Health and Environmental Sciences
Cogswell Building
Helena, MT 59620
(406) 444-5320

Purpose of Report

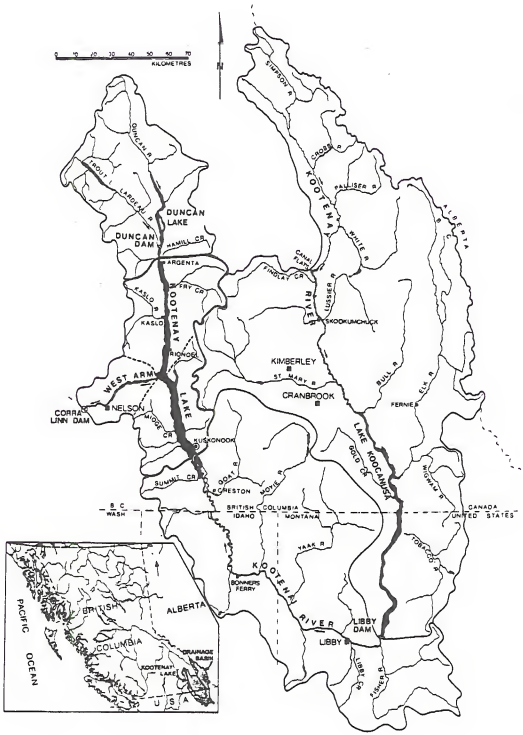
Land and water use activities, especially hydropower operations, logging and mining, have influenced the water quality, fisheries and recreational resources of the Kootenay Basin. The purpose of this report is to:

- provide a history and description of the Kootenay River Basin upstream from Kootenay Lake, BC;
- discuss current water quality issues, development activities and aquatic resources in the basin;
- give an overview of past, present and potential future environmental issues and problems in the basin; and
- make recommendations for prioritizing the basin's water quality concerns and critical issues, delineating subbasin management units and establishing better interagency communications, citizen participation and water quality monitoring.

Description of the Kootenay River Basin

The Kootenay River drainage basin is an international watershed, straddling the Canadian/United States border at the 49th parallel along the eastern rim of the Columbia River Basin. (Figure 1.) About two-thirds of the 36,000-km^2 (14,000-mi^2) watershed addressed in this report is within the province of British Columbia, with 9700 km^2 (3750 mi^2) in the state of Montana and roughly 3000 km^2 (1150 mi^2) in the state of Idaho. Nearly two-thirds of the river's 485-mile (775-km) channel length is within British Columbia. The Kootenay Basin is a heavily forested, mountainous watershed. The Continental

Figure 1
Map of the Kootenay Basin



Divide forms much of the eastern watershed boundary, with the Selkirk Mountains on the west, the Cabinet Range to the south and the Purcell Mountains filling the center of the river's "J"-shaped course to Kootenay Lake (Figure 2).

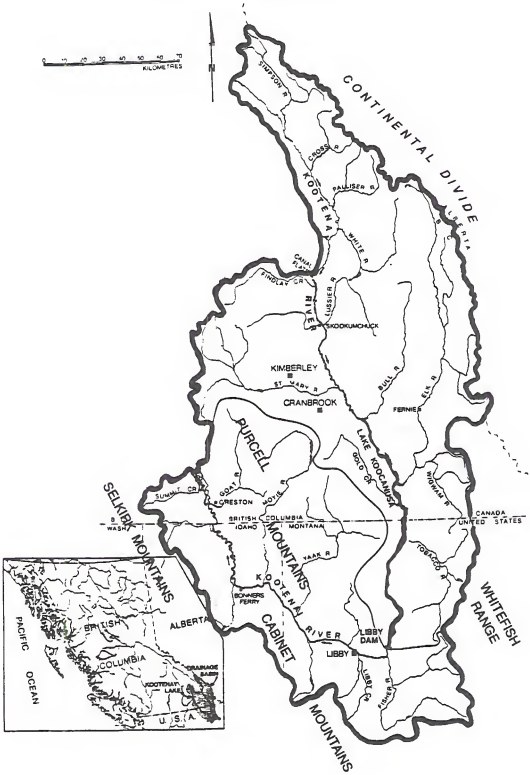
The Kootenay River originates in Kootenay National Park north of Mt. Assiniboine, the highest point in the basin at 3618 meters (11,867 feet). The river initially flows south within the Rocky Mountain Trench turning west through a gap between the Purcell and Cabinet mountains before heading north within the Purcell Trench to Kootenay Lake. At its confluence with the lake, the river's elevation is 532 meters (1745 feet), nearly 10,000 vertical feet below its high mountain origins.

The Continental Divide Range with crest elevations of 10,000 to 11,500 feet along nearly 250 km (155 miles) of ridgeline, is a major water source for the river, receiving 2000 to 3000 mm (80 to 120 inches) of precipitation annually (Bonde, 1987). Some of the high elevation country in the Purcell Range around Mt. Findlay, elevation 3163 meters (10,371 feet), receives approximately 2000 mm of precipitation per year; but most of the rest of this range along with the Selkirk and Cabinets, with ridgecrest elevations of 7000 to 9000 feet, receive approximately 1000 to 1500 mm (40 to 60 inches) annually (Daley et al., 1981). In the inhabited valley bottoms, annual precipitation varies from just less than 500 mm (20 inches) at Rexford, Montana (USACE, 1974) and Creston, British Columbia (Daley et al., 1981) to just over 1000 mm (40 inches) at Fernie, British Columbia (Oliver, 1979).

These relatively abundant precipitation levels make the Kootenay River the second largest tributary of the Columbia in terms of runoff volume, even though it is only the third largest in terms of drainage area. Only the Snake River contributes more volume to the Columbia, but does so from a considerably larger watershed than the Kootenay's (USACE, 1971).

The topography of the Kootenay River Basin is dominated by steep mountain canyons and valleys. Consequently, nearly all of the major tributaries to the river, including the Elk, Bull, White, Lussier and Vermillion rivers have a very high channel gradient, particularly in their headwaters. In contrast, the mainstem of the Kootenay River has a fairly low channel gradient after entering the Rocky Mountain Trench near Canal Flats. The river drops less than 1000 feet (305 meters) in elevation from Canal Flats to Kootenay Lake, a distance of over 300 miles (480 km). However, even along the river's slow

Figure 2
Portion of the Kootenay River Basin
discussed in this report



meandering course, valley bottom widths are generally less than two miles and are characterized by tree-covered rolling hills with few grassland openings. The only exceptions to this topography are the slightly wider valley bottoms in the Bonners Ferry-to-Creston area and the Tobacco Plains, located between Eureka, Montana and Grasmere, British Columbia.

It is at the latter location that, until 1890, the Native American inhabitants of the basin gathered once a year for religious festivals, particularly their version of the widely practiced Sun Dance (Hungry Wolf and Hungry Wolf, 1989). During the rest of the season, the Kutenai people (or "man of the Tobacco Plains" or "woman of the Columbia Lakes Band" as they generally spoke of themselves) lived a nomadic existence, with members scattered out in smaller groups to hunt or gather. Preference for either fishing or hunting divided the Kutenai tribe, or nation, into two harmonious segments. The so-called "upper Kutenai" lived closer to the Rocky Mountains, kept larger horse herds and made trips to the Great Plains once or twice a year to hunt buffalo. Their surplus buffalo and horses were traded to their "lower Kutenai" relatives, who preferred canoes over horses and staying near home waters to trap and spear fish or hunt birds and small game. As recently as 1890, virtually all Kootenay people made their living by hunting or fishing (op. cit.)

With the reservation system of the later 1800s most Native Americans were gathered and settled in large tribal groups. The Kutenais are among a minority who received much smaller reservations, essentially one for each of its scattered bands. As with most Native American Indian nations, there is a great deal of controversy surrounding the history of Kutenai reservations and land claims.

In 1808, the first geographic exploration of the upper Kootenai Basin, financed by the North West Company of Montreal, was conducted under the leadership of David Thompson. The following year Thompson and his French-Canadian crew built a structure called the "Kootennay Post" near present-day Libby. Three years later the post was relocated further upstream where it became a major fur trading post until closing in 1847 (Malone and Roeder, 1976). A mission station was established on the Tobacco Plains in 1845 by Father DeSmet, a Jesuit priest. The community of Libby was established in 1862, largely in response to a gold rush (USACE, 1971). China Rapids, in the river below Libby,

are named for a group of Chinese gold miners who lost their lives in the 1860s when their raft was overturned by the churning whitewater (Fisher, 1979). Accessibility to the Kootenay Basin was limited until completion of the Great Northern Railroad in 1893 and the Canadian Pacific Railroad in 1898, the year Cranbrook was established. Steamboat travel was active between Jennings, just up-river from Libby, and Ft. Steele, British Columbia from 1892 until 1900 when a railroad connecting Jennings and Fernie, BC ended the Kootenay's brief river transportation era.

Despite the presence of the railroads and, since the 1930s, several major highways, the Kootenay Basin remains relatively remote and sparsely populated. Fewer then 100,000 people live within the basin upstream from Kootenay Lake, which is an area larger than the states of Maryland and Delaware combined. The largest municipal center is the Cranbrook/Kimberley area with a population of about 25,000. Only six other communities in the basin have populations larger than 2000–Libby, MT; Bonners Ferry, ID; and Fernie, Sparwood, Elkford and Creston, BC.

The Kootenay Basin can be most aptly described as an interconnected series of breathtaking panoramas joining mountains, forests, lakes and streams. These natural amenities provide diverse recreational opportunities for basin residents and visitors. The combination of wide open spaces and spectacular scenery forms the basis of a significant industry based upon tourism, which continues to grow steadily.

The forest products industry remains the most dominant and extensive employment and development activity in the Kootenay Basin. This is not surprising since nearly 90% of the basin is either forests or high elevation, above-treeline ridges and mountain peaks. Logging and associated road building has occurred throughout the Kootenay Basin, in nearly all of the lower elevation valleys as well as on many higher elevation ridges. The intensity of this development increased substantially in the 1960s and 1970s, when utilization of clearcuts became widespread. Unroaded parcels of land (or roadless areas) larger than 5000 acres are uncommon in the Kootenay Basin. Only nine roadless areas totaling 139,600 acres exist in the Idaho portion of the basin (IPNF, 1991). In the Montana portion nine roadless areas totaling 241,500 acres are present, including approximately 60,000 acres of upper Libby and Lake creeks that are within the Cabinet Mountains

Wilderness Area (KNF, 1987). The largest contiguous block of land without logging roads in the British Columbia portion of the Kootenay Basin is the 390,000-acre Kootenay/Mt. Assiniboine National and Provincial Parks (Rocchini, 1981). Approximately 150,000 acres of the headwaters of the St. Mary River and Findlay Creek northwest of Cranbrook/Kimberley are within the Purcell Wilderness Conservancy. The total surface area of the above undeveloped areas amounts to about 10% of the Kootenay Basin above Kootenay Lake.

The Kootenay River Basin is home to four native salmonid species–bull trout (*Salvelinus confluentus*), westslope cutthroat trout (*Oncorhynchus clarki lewiski*), the Kootenay Lake strain of kokanee salmon (*Oncorhynchus nerka*) and the interior or redband strain of rainbow trout (*Oncorhynchus mykiss*). The Kootenay Lake Kokanee population has steadily declined in recent years, but these fish historically utilized river tributaries between the lake and Kootenai Falls for spawning and rearing. Isolated, pure-strain populations of redband rainbow trout are found in some tributaries downstream of Kootenai Falls. Genetically pure populations of westslope cutthroat trout are uncommon in the United States' portion of the basin, but healthy populations of this species are found in the Canadian portion; i.e., within the Elk, St. Mary and Goat rivers, Gold Creek and the upper Kootenay River. Due to loss of habitat, competition with introduced species, overharvest, alteration of stream discharges and other factors, bull trout appear to be in a decline throughout the United States' portion of the Columbia River. Once a highly sought trophy fish, with adults often weighing over 15 pounds, the bull trout is presently being considered for listing as a threatened or endangered (T and E) species.

The white sturgeon (*Acipenser transmontanus*), a living relic of the dinosaur era, is also presently being considered for a T and E listing. Adult sturgeon, often over 6 feet in length and weighing over 100 pounds, have not successfully reproduced in the lower Kootenay River since the completion of Libby Dam.

Coal and hard rock mining are also prominent activities in the basin, particularly along the Elk and St. Mary rivers and in the northern Cabinet Mountains. Underground coal mining began in the Elk River watershed around the turn of the century, with large-scale open-pit mining beginning in the early 1970s. Hard rock and lode mining started in the Cabinet Mountains and the St. Mary watershed between 1905 and 1920

and then collapsed during the depression years. Since the late 1930s the Sullivan Mine at Kimberley, BC has been the largest metal producer in the basin. In 1981 it was one of the two largest lead-zinc mines in the world (Daley et al., 1981). From 1981 to the present a large copper and silver mine and chemical floatation mill has operated in the Lake Creek watershed south of Troy, MT.

The production of hydroelectric energy is also an important industry. Along with the Libby Dam/Lake Koocanusa complex, which is by far the largest human-made structure in the basin, six smaller hydroelectric dams are located on the Elk, Bull, Moyie and Goat rivers as well as on Smith and Lake creeks.

Given the basin's rugged topography, agricultural development is limited and primarily confined to narrow valley bottoms. The largest contiguous block of agricultural land is within the Purcell Trench, which extends roughly from Bonners Ferry, ID to the river's entry into Kootenay Lake. Production of oats, wheat and barley account for 62% of the agricultural output in the Bonners Ferry/Creston area, with livestock production accounting for 20%. Hay and grass seed production and livestock grazing are the most common agricultural activities in the rest of the basin.

An Overview of Water Quality Protection Statutes

Water quality protection standards, objectives and/or criteria are not uniform across international, state, provincial and tribal jurisdictions within the Kootenay River Basin. Differences exist not only in numerical values; e.g. allowable instream concentrations of potential pollutants, but also in how these standards or criteria are applied during regulation of water pollution. With these regulatory differences, it is difficult to clearly define basin-wide water quality management plans, goals or objectives.

In Montana and Idaho, two state agencies administer water pollution control programs–the Montana Department of Health and Environmental Sciences, Water Quality Bureau and the Idaho Department of Health and Welfare, Division of Environmental Quality. The enforcement and regulatory power of these agencies is derived from the federal Clean Water Act and each states' Water Pollution Control Act. Since the 1960s, both states have had legally enforceable water

quality standards. Violation of these standards can result in fines of up to $10,000 per day. Since 1972, the state water quality standards have been periodically reviewed and approved by the U.S. Environmental Protection Agency. The federal government also provides the majority of the funding for state water pollution control programs. Both states' water quality standards are based upon protection of "designated or beneficial uses" of a given waterbody. Regulations preventing degradation of surface and groundwater are included in the states' standards, but exemptions can be granted for social and economic reasons by the Idaho Board of Health and Welfare or the Montana Board of Health and Environmental Sciences.

In British Columbia, the Provincial Ministry of the Environmental administers most water pollution control efforts with technical assistance from Environment Canada, a federal entity. Legislation similar to the Clean Water Act does not exist in Canada (Adamache, 1993). There are no water quality standards in British Columbia, per se; rather, the province has established industry-specific "receiving water objectives" and is in the process of developing province-wide water quality criteria. These criteria are intended to be used primarily for screening data or identifying problem areas, and they appear to be legally unenforceable (Mah, 1993). However, water pollution in Canada can also be controlled under the auspices of the federal Fisheries Act. This legislation, in essence, can regulate the discharge of "deleterious substances" to streams where fish habitat could be adversely affected. The provisions of this act potentially gives the Ministry of the Environment, Fisheries Branch much more authority to prevent damage to fisheries and water quality than is legally available to the Idaho Fish and Game, Montana Department of Fish, Wildlife and Parks or the U.S. Fish and Wildlife Service. The U.S. Endangered Species Act, administered by the latter agency, is certainly not as broad in scope and application.

The water-use classification of the Kootenay River in Montana is "B-1", which means its waters are "suitable for drinking, culinary and food processing purposes, after conventional treatment; bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply." In Idaho, the river is protected for several designated uses, including agricultural and domestic water supplies, cold water biota, salmonid spawning, as well as

primary and secondary contact recreation (swimming and other water sports); the Idaho portion of the river is also classified as a Special Resource Water. Table 1 compares the numerical values of select instream water quality standards for Montana and Idaho, which have been promulgated to protect the above stream uses. Also included in this table, are recommended criteria to protect similar water uses in British Columbia as presented in the latest version of *Approved and Working Criteria for Water Quality* (Pommen, 1991).

The information in this table underscores a few of the differences in the numerical standards and criteria being applied to waters in the basin. Differences in the color/colour standard/criteria is an obvious concern, given the presence of a large pulp mill next to the river near Skookumchuck, BC. Other differences exist as well, particularly regarding the control and regulation of toxic and hazardous substances, and sediment runoff from logging and road building operations. Pertinent to the latter, the British Columbia criteria for "particulate matter" is much more direct than in Montana or Idaho, suggesting that "no accumulation (at the 95% confidence level) of particles less than 3 mm should occur within salmonid spawning areas." Logging and road building in Idaho is regulated by provisions of the state's Forest Practices Act. Similar legislation does not exist in Montana.

At present, there are no tribal water quality standards in place within the Kootenay River Basin. But, the Kootenay Tribe of Idaho is presently in the process of developing the legal protocols necessary to establish standards and other regulations within a, yet undetermined, portion of the basin (Hopkins, 1993). This legal process will also require coordination with the confederated Salish Kootenai Tribe of Montana, which also has potential jurisdictional authority within the basin.

Table 1
Comparison of Numerical Water Quality Standards/Criteria
for Surface Waters in the Kootenay River Basin

Water Use	Parameter	Units	MT	ID	BC
Trout and associated aquatic life	Dissolved oxygen (minimum allowable concentration)	mg/l	7.0	6.0	8.75 high protection 6.75 mod. protection
Trout and associated aquatic life	pH (allowable instream range)	standard units	6.5-8.5	6.5-9.5	6.5-9.0
Trout and associated aquatic life	Water Temperature (maximum allowable increase over natural levels--MT & BC; maximum instream temp.--ID)	°F or °C	1°F	22°C; max. ave. less than 19°C	1°C
Primary contact recreation	Fecal Coliforms (maximum instream concentration; 30-day average)	organisms/ 100 ml	200	200	200
Aesthetics	Color (Colour) (maximum allowable increase over natural instream levels)	standard units	5	no numerical value	15

An Assessment of Existing and Potential Effects to Water Resources

Hydroelectric Facilities

Since the mid-1970s Libby Dam and its reservoir have continued to influence the water quality, fisheries and recreational value of the Kootenay River and Kootenay Lake to a greater degree than any other single facility or pollution source. The dam was authorized by the Columbia River International Treaty of 1964. Construction began in 1966 and was completed in 1972.

Spanning 3055 feet in width and rising 446 feet above bedrock, Libby Dam converted 144 km (90 miles) and 4750 acres of the free-flowing Kootenay River to a reservoir with 366 km (229 miles) of shoreline. At full pool, the reservoir has a surface area of 46,500 acres, which is roughly one-third the size of Flathead Lake. About 60% of the reservoir is in Montana, with the rest in British Columbia. The total storage capacity is 5.9 million acre-feet (USACE, 1971).

As envisioned by the Flood Control Act of 1950, the dam was constructed to control floods and produce hydroelectric energy. It has accomplished both purposes. Over 50,000 acres of fertile land along 110 km (70 miles) of the river's floodplain upstream from Kootenay Lake was historically inundated during spring runoff. This former floodplain area, 66% in Idaho and 34% in British Columbia, now produces agricultural crops. The flood control benefits of the dam have also extended to the lower Columbia River, since the Kootenay River historically contributed nearly 10% of the total spring runoff flows of the Columbia River at The Dalles, Oregon (op. cit.). The turbines at Libby Dam produce 270 megawatts (MW) of firm electric power and have a maximum rated capacity of 525 MW (Bonde, 1987). Storage releases from the dam also enhance power production at 15 downstream dams (10 in the U.S. and 5 in Canada) by roughly 550 MW (USACE, 1971).

The above benefits, however, have not come without a concurrent cost to the Kootenay Basin's fish, wildlife and water quality resources. The 144 km of free-flowing river and 44 km of tributaries now inundated by the reservoir (Ringstad and Oliver, 1979) formerly supported naturally reproducing populations of native westslope cutthroat and bull trout. In fact, prior to the construction of Libby Dam, this portion of the Kootenay River supported one of the most productive cutthroat trout fisheries in North America (Fisher, 1979). Both of these species still exist in the reservoir, but the cutthroat population continues to decline. Despite intensive planting of hatchery cutthroat; e.g., 4 million fish from 1972-1976 and nearly 3 million from 1981-1986, gill net sampling by fish managers has demonstrated a steady reduction in numbers of this species in the reservoir. Gill net catches of cutthroat, which averaged over 2.0 fish per net in 1975-1978, declined to 1.3 fish per net in 1979-1982 and 0.7 fish in 1983-1986. Catch rates by anglers has dropped even more significantly, from 1.0 to 1.5 trout per hour during 1949-1964 to only 0.04 trout per hour in 1985 (Bonde, 1987). Meanwhile, rough fish like peamouth, northern squawfish and suckers dominate the fisheries biomass of the reservoir (Chisholm et al., 1989).

The principal sportfish in the reservoir in recent years has been a non-native strain of Okanagon Lake kokanee salmon, which were accidentally introduced to the Kootenay River in 1979 from a brood source at the Kootenay Hatchery near Wardner, BC. The population of this species increased dramatically from 1981 to 1986. However, in conjunction with this population boom, the average size of the individual fish decreased. Although catch rates for kokanee during 1985 were fairly high, 0.4 to 1.6 fish per hour depending on the season, complaints began to be expressed regarding the smaller average length and weight of fish. Fish managers in British Columbia began introducing Kamloops rainbow trout to the reservoir in 1986 in an effort to reduce the kokanee numbers and produce a trophy fishery. In 1987, the Montana Department of Fish, Wildlife and Parks also began changing the emphasis of its Murray Springs Fish Hatchery near Eureka from cutthroat to Kamloops rearing.

To satisfy power production demands at Libby Dam and other downstream power facilities, annual filling and drafting of the reservoir occurs, causing drawdowns typically exceeding 100 feet in pool levels (USACE, 1974). The effects of these

drawdowns are most noticeable in British Columbia, where the aquatic environment annually fluctuates between lake and river habitat. During dry years, the reservoir doesn't completely fill, leaving upper reservoir boat docks high and dry.

Fisheries, water quality and recreation in the river below the dam and in Kootenay Lake have also been influenced by operation of Libby Dam and its reservoir. Real or potential effects include disruption of naturally occurring water temperature and stream discharge conditions, increases in dissolved gases (supersaturation) and decreases in essential trace elements; i.e., nutrients that stimulate aquatic plant growth.

Better control of downstream water temperature was achieved in 1977 with the installation of a selective withdrawal system, which controls the level from which water is directed to the turbines. Although pre-existing water temperature regimes in the river below the dam are not perfectly duplicated, this system appears to have improved downstream conditions over those existing prior to placing the withdrawal system into operation. Since 1978 water temperatures just below the dam have, on the average, been about 17% warmer than during pre-dam years (Bonde, 1987). This increase in water temperature appears to have benefited the growth of salmonids, at least immediately below the dam, where the state weight record for rainbow trout has been broken three times in recent years.

Water flowing over the spillway or through sluices at Libby Dam has caused increased levels of dissolved gases (supersaturation) in the river. From 1972 to 1975 supersaturated gasses, originating from the above sources, caused "popeye" or gas bubble disease in fish. In September 1972, 60 to 80% of trout and mountain whitefish (*Prosopium willamsoni*) 17 to 21 miles below the dam demonstrated signs of gas bubble disease (USACE, 1974). Upon completion of the dam's turbine system in 1975 the incidence of this problem has been substantially reduced, occurring only when water releases exceed the powerhouse hydraulic capacity of 28,000 cubic feet per second (Bonde, 1987).

The operation of Libby Dam drastically alters downriver discharge patterns on a seasonal and, sometimes, daily basis. Peak river discharge rates of 64,000 cubic feet per second (cfs) that formerly occurred during spring runoff at a two-year recurrence interval, have been replaced with regulated releases

ranging from roughly 5000-10,000 cfs during summer to 15,000-25,000 cfs during winter (op. cit.). As well, during many months it is not uncommon for river discharge rates to fluctuate widely between approximately 5000 and 20,000 cfs (Figure 3). These fluctuations are an obvious detriment to river floaters and other recreational water users.

Elimination of peak discharges during spring runoff, and associated reductions in water velocities within spawning areas and other habitats, also appears to be the major factor that has prevented successful spawning by white sturgeon in the Kootenay River since 1977 (Partridge, 1983; Anders, 1991). Figure 4 displays monthly flow, temperature and photoperiod conditions for the Kootenay River at Porthill in relation to the white sturgeon spawning season (Apperson, 1992). Figure 5 further compares the annual stream discharge hydrograph at Bonners Ferry during 1974–a year when white sturgeon successfully spawned–to a discharge pattern recommended by Apperson (1992) to enhance sturgeon spawning in the future.

The reservoir behind Libby Dam has been linked to the decline of primary productivity rates and subsequently the kokanee population in Kootenay Lake (Daley et al., 1981; Ashley and Thompson, 1993). Primary productivity refers to the growth of suspended algae (phytoplankton) and attached algae (periphyton) which are the principal food of small, lake-dwelling crustaceans (zooplankton). Zooplankton, in turn, are the major food source for kokanee. Algae require certain essential micronutrients, particularly nitrogen and phosphorus compounds, for their growth. Reservoirs often become "nutrient sinks"; e.g., reducing the downstream availability of nutrients, because of two factors. First, algae and other aquatic plants (macrophytes) within reservoirs consume nutrients which settle to the reservoir bottom upon death of the aquatic organisms. Second, spring runoff flows, which typically contain the highest concentrations and/or loads of nutrients are stored for subsequent release during autumn and winter. Nutrient input patterns to downstream water bodies are thereby seriously disrupted. Daley et al. (1981) estimated that phosphorus delivery rates to Kootenay Lake during the spring and summer growing season have been reduced by about 50% because of the presence of Libby Dam and its reservoir.

Other factors, most notably the influence of mysis shrimp, which were introduced to Kootenay lake in 1950, may also have contributed to the decline of the kokanee population. Lake

Figure 3
Hydrograph of the Kootenay River below Libby Dam
(from Reller, 1993)

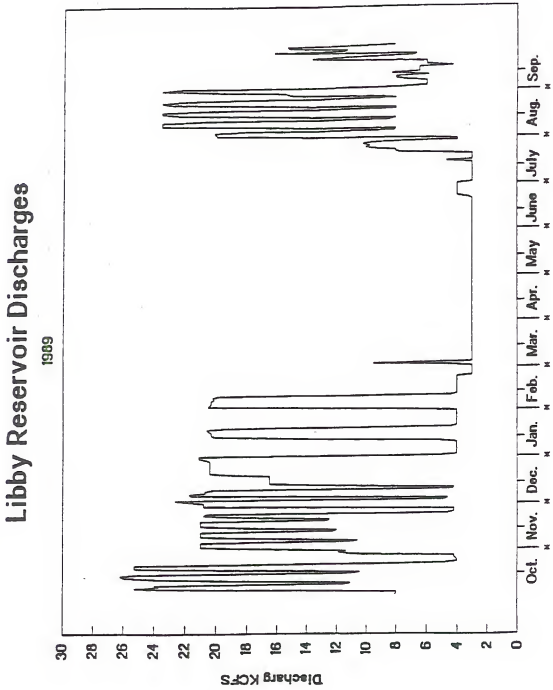
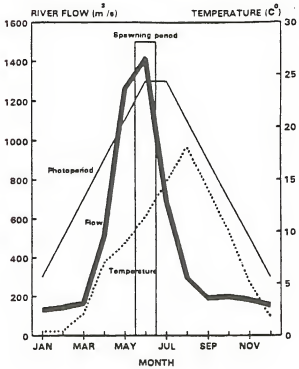


Figure 4
Mean monthly flow, water temperature and relative photoperiod in the Kootenay River at Porthill, Idaho before and after the operation of Libby Dam (from Apperson, 1992)

PRE-DAM



POST-DAM

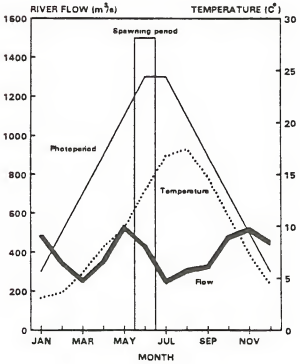
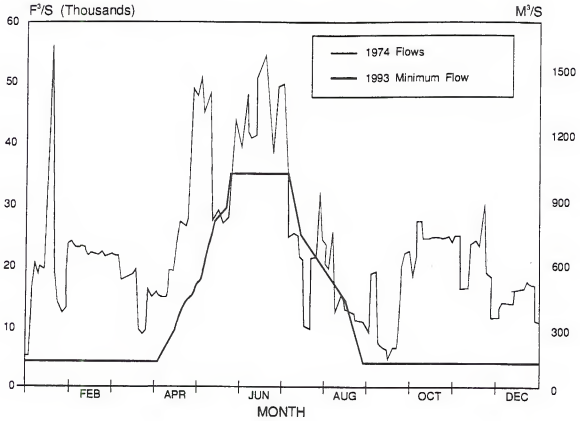


Figure 5
Recommended minimum discharge in the Kootenay River
at Bonners Ferry to enhance white sturgeon spawning
(from Apperson, 1992)



fertilization experiments, which commenced in 1992 (Ashley and Thompson, 1993), may eventually help revitalize the kokanee population or at least determine whether the loss of nutrients is the major factor responsible for its decline. Even if successful, however, artificial fertilization will be a costly, maintenance-intensive program.

Mining

Acid-mine Drainage

Sulphide ores exposed to the atmosphere and water during hardrock mining produce sulfuric acid. This acidic, or low pH water, dissolves heavy metals; i.e., cadmium, copper, lead and zinc from the ore body, causing an acid-mine drainage (AMD). Trout and associated aquatic life are generally much more sensitive to the toxic effects of heavy metals than are humans or other mammals. Recommended instream levels for the protection of trout and other aquatic life, or concentrations that should not be exceeded for extended periods at a water hardness of 100 mg/l are 1.1, 3.2, 11.0 and 120 ug/l, respectively, for cadmium, lead, copper and zinc (USEPA, 1986). The respective criteria in British Columbia are 0.8, 3.2, 4.0 and 30 ug/l (McDonald, 1993). The U.S. EPA values are total recoverable concentrations; the BC values are total concentrations. Drinking water standards, or concentrations considered safe for human and livestock consumption, for these metals are generally 10 to 15 times higher. The trout fishery of certain streams within the Kootenay Basin have been impacted by AMD.

The Sullivan Mine, at Kimberley, which is operated by Cominco, has been in production since 1900. As of 1973, total production at the mine had been approximately six million tons of zinc, seven million tons of lead and 24 million ounces of silver. A concentrator capable of processing 2500 tons of ore per day was started in 1923; by 1973 the concentrator's capacity had been increased to 10,000 tons per day (Rocchini et al., 1976 B). Until 1979 AMD from the mine and concentrator was discharged, untreated, into Mark, Kimberley and James creeks, which are tributaries of the St. Mary River. Wastewater treatment facilities were completed at Cominco site in August 1979. The treatment process essentially increases the pH and

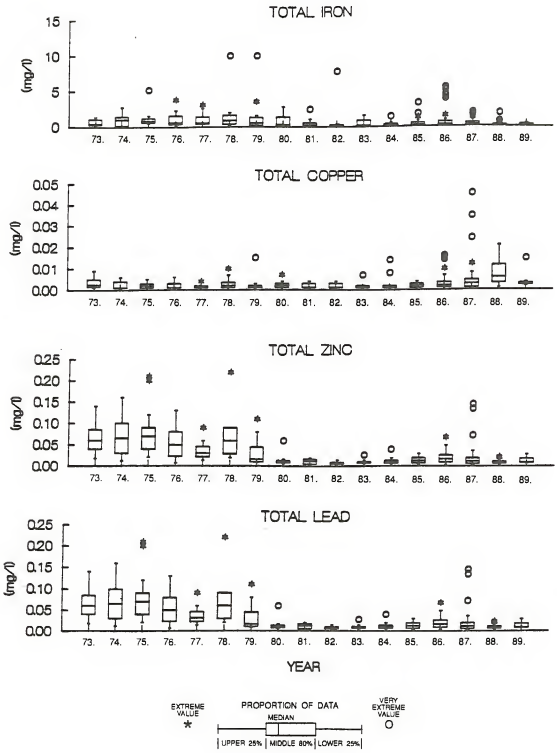
removes heavy metals by adding chemical flocculents to the AMD.

For decades prior to 1979, AMD from the Cominco operation negatively affected fish and aquatic life in the St. Mary River, its three aforementioned tributaries and quite likely the Kootenay River. The strength and duration of this impact were not quantified in the St. Mary and upper Kootenay rivers until the mid to late 1960s. Monitoring from 1969 to 1974 by the BC Ministry of Environment found lead values as high as 70 ug/l near the mouth of the St. Mary River (Rocchini et al., 1976 B). Lead concentrations exceeding 20 ug/l were found in the Kootenay River downstream from the St. Mary River in 1975 and 1978 (Hamilton et al., 1990). In 1975 AMD at the Cominco site contained lead concentrations of 6800 ug/l; zinc concentrations were 10,200 ug/l. In 1990, discharges from the treatment plant contained average concentrations of 30 ug/l for lead and 250 ug/l for zinc. The benefits of the treatment plant upon the water quality of the Kootenay River can be seen in Figure 6. These heavy metal data, for the Kootenay River below the St. Mary from 1973 to 1989, demonstrate that instream concentrations of heavy metals, particularly zinc and lead decreased significantly after treatment was initiated in 1979.

Since early in this century, hard rock, placer and lode mining has occurred in the Cabinet Mountains and, to a lesser extent, in the Selkirk Range. AMD from the Snowshoe Mine in the Libby Creek watershed has affected trout populations in three miles of Snowshoe Creek and 15 miles of Big Cherry Creek for over 70 years. Efforts are currently underway to reclaim this site, but other abandoned mines are possibly in need of similar attention, including the extensively mined area south of Great Northern Mountain in the Fisher Creek drainage; abandoned mines and associated workings along lower Boulder Creek; and, in the Selkirk Mountains, the Continental Mine in the headwaters of Boundary Creek.

The Noranda Minerals Corporation is proposing to develop a large copper and silver mine complex in the Libby Creek watershed just north of the Snowshoe AMD site (USFS et al., 1992). Ore production from an underground mine would be 20,000 tons per day. Based upon estimates of ore reserves, silver production would be around 8 million ounces per year. The 112 million tons of tailings produced during the

Figure 6
Heavy metal concentrations in the Kootenay River
below the St. Mary River 1973-1989
(from Hamilton et al., 1990)



anticipated 16 years of operation would be stored behind a 370-foot-high dam. The tailings pond and associated structures could eventually cover 994 acres of the valley bottom of Little Cherry Creek. A diversion dam upstream of the tailings impoundment would reroute the surface flow of Little Cherry Creek into an unnamed tributary of Libby Creek (op. cit.).

A similar-sized mine and ore concentration facility has been in operation in the Lake Creek watershed for nearly 15 years. The tailings impoundment for this ASARCO development covers about a square mile of Lake Creek's floodplain and low valley bottom approximately 15 miles upstream of its mouth near Troy, MT. Because of the close proximity of this facility to an important trout fishery, careful reclamation and continued water quality monitoring is necessary to ensure that potential water quality problems will not affect Lake Creek.

Fertilizer Production

Starting in 1953, Cominco, Ltd. also operated an ammonium phosphate fertilizer plant at Kimberley. Plant expansions in 1963 and 1965 increased yearly production levels to 166,000 tons. Annual discharges of phosphate from the plant to the St. Mary River and thence to the Kootenay River and Lake exceeded 8,000 tons in the mid to late 1960s (Northcote, 1972). As shown in Figure 7, phosphate and ammonia concentrations in the plant's effluent decreased following installation of pollution abatement measures in November 1975 (Rocchini, 1981). Fertilizer production rates decreased in the late 1970s and the plant closed in 1987. The resulting reductions in phosphate discharges to the river can be seen in Figure 8 which compares soluble reactive phosphorus concentrations in the Kootenay River below the St. Mary River to concentrations in the Elk River from 1968 to 1989. Figure 9 further displays the reductions that occurred during the 1980s and especially after 1987. (Note the differences in period of record and concentration scales between Figure 8 and Figure 9.)

The boom in the kokanee population in Kootenay Lake that occurred from the mid 1950s to the late 1970s was largely an artificial response triggered by high concentrations of phosphorus being discharged from the fertilizer plant. The closure of this plant, in combination with Libby Reservoir functioning as a nutrient sink, has essentially produced an opposite situation. Public attitudes about the latter can differ in adjacent river basins. In the Clark Fork/Lake Pend Oreille

Figure 7
Orthophosphorus and ammonia concentrations
in Cominco's effluent 1975-1979
(from Rocchini, 1981)

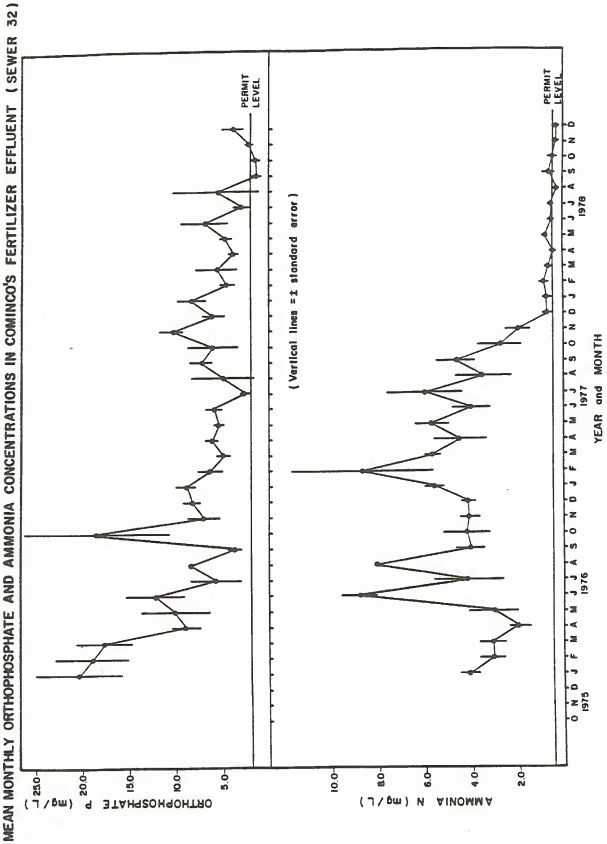


Figure 8
Soluble reactive phosphorus concentrations
in the Kootenay River (below the St. Mary River)
vs. the Elk River 1968-1989
(from Hamilton et al., 1990)

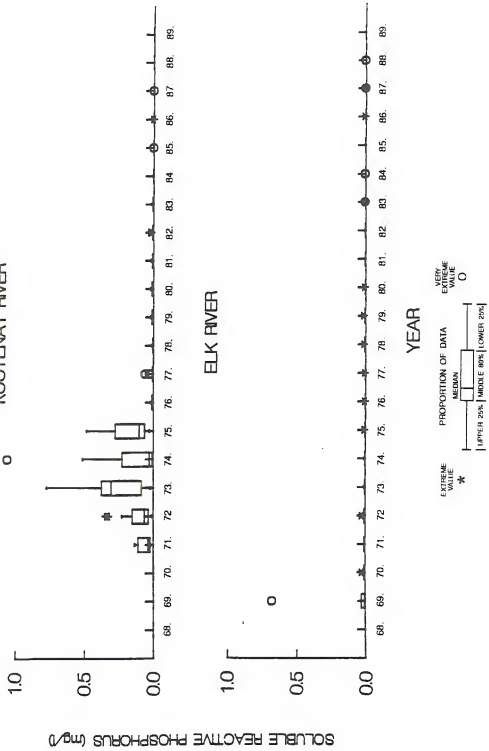
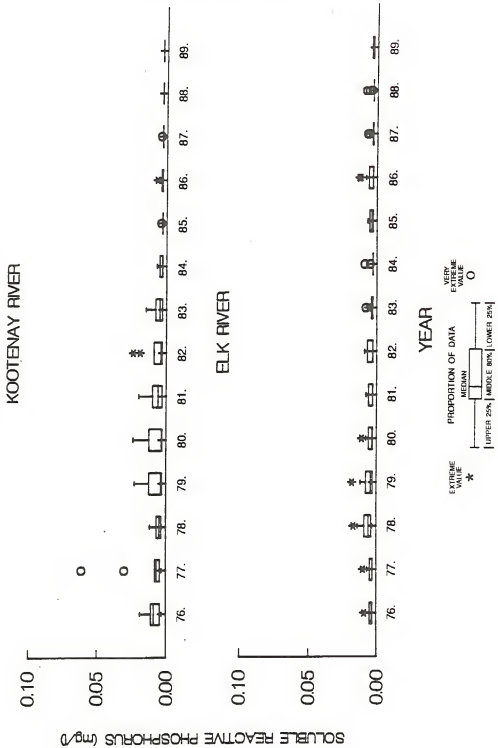


Figure 9
Soluble reactive phosphorus concentrations
in the Kootenay River (below the St. Mary River)
vs. the Elk River 1979-1989
(from Hamilton et al., 1990)



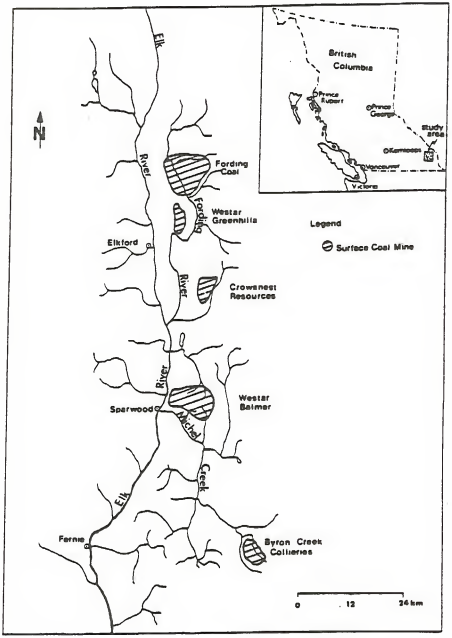
Lake Basin, dams on the lower Clark Fork River also serve as nutrient sinks. But, keeping Lake Pend Oreille clear; e.g., free of excessive phytoplankton blooms that reduce water clarity, is a major water resource management goal. Even though Libby Reservoir provides the same function for Kootenay Lake, water resource goals appear to be directed towards producing more phytoplankton. The resulting increased fish production is apparently regarded as being more important than clearer, more aesthetically pleasing water. It is important to note, however, that the artificial fertilization thus far has had little effect on Kootenay Lake's water clarity (McDonald, 1993).

Coal

Although some underground coal mining has occurred in the Elk River Basin since 1898, it was not until the late 1960s that large-scale surface mining began. The first major companies to start production were Fording Coal, Ltd. in the Fording River watershed and Kaiser Resources, Ltd. (presently Westar Balmer) near Sparwood. Mines and overburden at the Fording operation were expected to cover 940 hectares (2300 acres) by 1980 (BC Min. Env., 1978) with approximately 50 million tons of overburden and 100 acres of additional land planned to be disturbed per year in the 1980s (Rocchini et al., 1976 A). In fact, by 1987 the total disturbed area at Fording Coal covered nearly 2000 hectares or over eight square miles (MacDonald and McDonald, 1987). As part of its exploration activities from 1969 to 1973, Kaiser Resources constructed 218 miles of road and 375 miles of bulldozed seam trenches within its extensive coal reserve area. Annual coal production during the late 1970s at Fording Coal was 2 to 3 million tons per year, while 5 to 6 million tons were annually produced at Kaiser Resources (BC Min. Env., 1978). Currently, there are five large surface mines operating in the Elk River Basin (Figure 10). Total mine production by 1989 was 17 million tons (Hamilton et al., 1990).

Unlike many other large coal producing areas in North America and Europe, the coal and associated overburden in the Elk River Basin is very low in sulfur and therefore does not produce any detectable AMD. Rather, the major water quality problem attributed to the coal fields is increased delivery rates of suspended sediment to the Elk River and its tributaries. Prior to the installation of properly functioning settling pond systems in the mid 1970s, tributaries such as Baldy, Otto, Goddard and Michel creeks were often black with coal dust

Figure 10
Locations and relative sizes of coal mines
in the Elk River Basin
(from MacDonald and McDonald, 1987)



during runoff periods (Rocchini et al., 1976 C). In larger streams like the Fording River, suspended sediment concentrations of up to 732 mg/l and turbidity levels as high as 240 nephelometric turbidity units (NTUs) were measured downstream of the Fording Mine in 1975 and 1976; upstream of the mine suspended sediment measurements in the river ranged from 0 to 21 mg/l and turbidity values never exceeded 3 NTUs (BC Min. Env., 1978). During 1975 and 1976 suspended solid concentrations in some waste streams originating at the Fording Mine were found to be as high as 80,700 mg/l.

In recent years, with the initiation of better runoff collection systems, settling ponds and selective use of chemical flocculents at the mines, suspended sediment concentrations in effluents are, under permit stipulations, not to exceed 50 mg/l. Even so, some impact still appears to be occurring to trout spawning and rearing habitat downstream of the mines. MacDonald and McDonald (1987) reported that the deposition of sediment in the Fording River below the mine likely reduces the success of trout egg survival. However, McDonald (1993) feels that these impacts are fairly localized and dissipate with increasing distance downstream. Potential effects to the trout fishery can be further reduced if disturbances near important spawning streams are minimized; and if highly erodible and easily dissolved materials such as mudstone are not exposed to runoff or used during settling pond construction (op. cit.).

Two other water quality parameters have been present at levels exceeding natural background concentrations. During the late 1970s nitrate concentrations in the Fording River below the mine were as high as 10.8 mg/l, compared to 0.05 mg/l above the mine (BC Min. Env., 1978). The drinking water standard for nitrate is 10.0 mg/l. Phenol concentrations in Michel Creek below the Kaiser Resources coke plant were found to be as high as 64 ug/l, while this organic compound was not present; i.e., below laboratory detection limits, above the plant. Phenol concentrations above 10 ug/l can impair the taste of fish.

Phenols are no longer an issue in the Elk River Basin, since the coke plant was closed in 1981 and the site has been subsequently reclaimed. Because there are no real alternatives to nitrogen-based explosives, nitrate levels are still elevated (although well below the drinking standard) in the Elk River and are often detectable as far downstream as the Libby Reservoir. However, since the river and reservoir are primarily

phosphorus-limited and since nitrate levels must exceed 40 mg/l before becoming toxic to aquatic life (Pommen, 1991), these somewhat elevated nitrate concentrations are of little environmental consequence. As well, the more highly toxic components of the explosives, ammonia and nitrite, usually dissipate within a few kilometers downstream of the mines (McDonald, 1993).

Forest Practices

Logging and Associated Road Building

Logging and road building occur throughout the Kootenay Basin, in areas where they are not constrained by topography, land suitability or designated wilderness areas and parks. About 80% of the commercial timberland in the U.S. portion of the basin is owned and managed by the federal government; i.e., the Kootenai and Idaho Panhandle National Forests. Most of the remaining commercial timberland is privately owned by Plum Creek, a large multi-state corporation. These private holdings are concentrated in the Fisher River watershed, which is predominantly privately owned, and to a lesser extent in lower-elevation portions of the Lake Creek watershed.

Logging activities within the national forests are governed by provisions established in the 1976 National Forest Management Act. This legislation directs each national forest to produce resource-based management plans, which are to be rewritten in 10- to 15-year cycles. "Timber sales" are offered to private companies in a competitive bid process.

The British Columbia portion of the basin is almost entirely "Crown Land." The BC Ministry of Forests apportions commercial timber under either the small business or major license programs. The former, which involves about 15% of the timber volume, is managed in a manner similar to the U.S. competitive bid process. The latter, much larger program, allows license holders to cut a prescribed annual volume of trees within their designated license area. License holders must annually update their five-year development plans, and submit preharvest silvicultural prescriptions to the Ministry of Forests for agency approval before proceeding with development of "cut blocks" (Byford, 1993). Crestbrook Forest Industries is the largest major license holder in the Canadian portion of the

Kootenay Basin, with Slocan Forest Products, J.H. Huscrofts, Wynndel Box and Lumber, and Galloway controlling cutting rights in much smaller licensed areas.

The major effect to water quality and trout populations caused by logging and road building is increased delivery rates of sediment to streams; other effects include increases in bedload movement and water yields. As discussed earlier, excessive deposits of fine-grained sediment can reduce survival rates of developing trout eggs; it can also reduce vital rearing habitat for juvenile trout when spaces between large gravels and cobble are filled.

In the Kootenay Basin, as in most of the Northern Rockies and Pacific Northwest, very little water quality monitoring has been conducted on streams potentially affected by logging operations. During a 1976 monitoring episode, runoff from a cutting area in the Fording River watershed was found to contain a suspended solids concentration of 6686 mg/l. In another instance, sediment runoff from roads and logging sites in the Grave Creek drainage (Elk River watershed) was so severe that water quality investigators felt that settling basins may be needed to protect the stream's water quality (BC Min. Env., 1978). In total, however, only scattered records of suspended solids and turbidity measurements are available for streams in the Kootenay Basin. As such, the effects of logging activities are only understood in general and qualitative terms. For example, Rocchini et al. (1976 B) state "Logging operations can be expected to contribute to soil erosion and sedimentation. Erosion of surface material has been observed, particularly along access roads in the Wild Horse, Galbraith and Lussier river valleys." The Environmental Impact Statement (EIS) for the Kootenai National Forest Plan states "Almost two-thirds of the Kootenai National Forest, particularly the west half, is subject to watershed problems; frequent flooding and concentrated high water yields, sedimentation, and small slumps below clearcuts and roads" (KNF, 1987).

Adding to the paucity of actual, on-site water quality monitoring is the lack of explicit water quality standards to protect fish and associated aquatic life from the effects of sediment runoff. Numerical guidelines or goals for reducing sediment delivery to streams are incorporated into the Kootenai and Idaho Panhandle forest plans. Actual monitoring on these forests is limited, however, primarily because of the

lack of personnel and adequate funding. For example, on the Kootenai National Forest total suspended solids and bedload monitoring was conducted on only seven "indicator streams" from 1987 to 1992. This effort represented only a small fraction of potentially affected streams. As well, the accuracy and reliability of the data was considered moderate and inconclusive (KNF, 1993).

Narrative criteria in present state and provincial statutes are not entirely clear in their intent or enforceability. Montana and Idaho Water Quality Standards state that sediment runoff should not "impair beneficial or designated uses." Canada's federal Fisheries Act prohibits "harmful alteration, disruption or destruction of fish habitat." The problem, of course, is defining, documenting or agreeing upon whether impairment or harm has occurred.

Part of the reason why state and provincial governments have been hesitant in adopting more explicit suspended sediment standards involves concern about accounting for natural or background levels of these potential pollutants. Also, since the effect of sediment is most damaging when it settles upon the streambottom, a numerical standard based only upon water column measurements may not be the best approach. Perhaps, as suggested by MacDonald and McDonald (1987), "Water quality guidelines (or criteria) should be developed for deposited sediment to reduce the risk of unacceptable impacts to habitat quality or stream biota." Various streambottom sediment or channel morphology measurements, and suggested criteria based on these measurements, have been proposed. None have been legally adopted by states or provinces. Perhaps what is needed is a combination of water column and streambottom measurements, with numerical or clear, compliance-directed narrative criteria for each.

Depending upon the soils and geology of road cuts and other areas disturbed by logging, sediment runoff can also be a source of nutrients to receiving streams. Logging within streamside or riparian areas can reduce thermal shading, causing increases in ambient stream temperatures. Bull trout are particularly sensitive to increased water temperatures, preferring waters that are cooler than 16°C (62°F). Skidding and road building adjacent to streams can also reduce the sediment-filtering capacity of riparian areas.

Sediment erosion caused by logging activities can be reduced if proper soil and water conservation measures or Best

Management Practices (BMPs) are carefully followed. Actual on-the-ground application of these procedures, including maintenance of buffer strips or streamside management areas along streams, varies throughout the Kootenay Basin. In Idaho, BMPs for logging and road building are mandatory as per the rules and regulations pertaining to the state's Forest Practices Act. In British Columbia and Montana the use of BMPs during these development activities is largely voluntary.

Milling and Manufacturing

Crestbrook Forest Industries began operating a pulp mill at the junction of Skookumchuck Creek and the Kootenay River in 1968. Production rates at start-up were 400 tons per day of bleached kraft pulp, which has increased presently to 580 tons per day. During the thirteen years following start-up, approximately fifteen million gallons per day of effluent was discharged directly into the Kootenay River after receiving secondary waste treatment in settling ponds and a 13-acre aeration basin.

From 1969 to 1974 effluent from the mill caused color, toxicity and fish tainting problems in the Kootenay River at least to the confluence of the St. Mary River, about 40 km below Skookumchuck (op. cit.). During 1976 to 1979 river color measurements were typically 30 to 40 standard color units at a station 18.5 km below the mill, compared to values typically less than 10 units above Skookumchuck (Rocchini, 1981). During the 1970s angler use of the river below Skookumchuck plummeted, partly in response to the dramatic discoloration of the river, especially during low flows (Whitfield and Oliver, 1983). All of the above investigators also felt that the pulp mill effluent was a source of at least sublethal toxicity to fish and aquatic life. The cause of this toxicity would have been chlorophenols, dioxins, furans and other organochlorine compounds characteristic of kraft pulp mill wastes. No water quality analyses were conducted to determine the presence or concentrations of these compounds during the 1970s, since suitable laboratory analytical techniques have only been available in recent years.

In December 1981 Crestbrook began disposing of its effluent, at least during low flow periods, through a series of seven 18.2-hectare rapid infiltration basins. This treatment technique allows the effluent to percolate through soils in the bottom of the basins and thence into the shallow groundwater

or alluvial aquifer. In the process, a combination of chemical, physical and biological interactions reduces the color, and presumably, the toxicity of the effluent. Studies conducted before and after implementation of the rapid infiltration system determined that concentrations of color and chlorinated organic compounds were significantly reduced (Op. cit). Although analyses for specific organic compounds could not be conducted, concentrations of "phenolic materials," which before 1982 were as high as 1800 ug/l just below the mill and 800 ug/l 40 km downstream, were reduced to 50 to 200 ug/l after the start of the rapid infiltration system. Color in the river was reduced even more significantly, although this data is hard to interpret. It was reported in "relative units" rather than in true color units.

In 1986, colored seepage began to appear in a channel of the Kootenay River near the rapid infiltration basins. In situ toxicity tests conducted immediately downstream from this seepage in 1987 and 1988 proved to be non-lethal to rainbow trout during 96-hour, 14-day and 40-day exposure tests. As well, detectable quantities of five specific chlorophenol compounds were not found in river water or fish from the bioassays. The compounds were found in the seepage, but at levels 97% less than the waste stream entering the rapid infiltration basins (McDonald, 1991).

While not totally definitive, the findings of the above study provided a level of assurance that the seepage reaching the Kootenay River in 1987 and 1988 was not having serious short-term toxic effects on fish. But, concerns for the future continue to exist, including the sludge landfill site which is located within the 100-year floodplain. By 1990 the seepage flow had increased to about 20% of the effluent flow, up from an estimated 10% in 1988; the two basins nearest the river were no longer used and there was a possibility that a failure or slide could occur. By 1991, it was apparent that surface discharges to the river during runoff would continue to be necessary, perhaps for increasingly longer periods, to give the five remaining rapid infiltration basins a seasonal rest. It was hoped this resting would prevent hydraulic saturation of the soils under the basins. However, beginning in 1992, a major upgrading of the mill began. A new recovery boiler has been installed that, in combination with improved brown stock washing, will reduce biochemical oxygen demand (BOD) by 50%. A new non-condensable gas incinerator will further

reduce BOD by 20%. Improved bleaching techniques and a color removal clarifier will allow discharge during low flows without river discoloration and will further remove BOD, total suspended solids and the toxic components of the effluent. By the end of 1994, all of the above treatment systems should be on-line and the rapid infiltration ponds can hopefully be phased out (McDonald, 1993).

The most recent evaluation of the pulp mill's effluent occurred during 1990. The BC Ministry of Environment instructed Crestbrook to implement a baseline organochlorine contaminants program in the Kootenay River from just above Skookumchuck to Lake Koocanusa. From May to September 1990 the mill's effluent, local drinking water supplies, river water, sediment, fish and macroinvertebrates were sampled at several locations for the presence and concentrations of organochlorines, including several forms of dioxins, furans and chlorinated phenols (Hatfield, 1991). Low concentrations of these compounds were found in fish tissue and bottom sediments at all sampling locations below the mill. As well, it was believed that the dioxins and furans were bioaccumulating in fish tissue. These findings, however, are reported as preliminary and "do not permit a meaningful comparison of organochlorine loadings in the receiving environment of the Kootenay River system, as a function of time, given an insufficient temporal data base" (op. cit).

Crestbrook Forest Industries is in the early stages of conducting an Environmental Effects Monitoring Program as required by the Pulp and Paper Regulation of the federal Fisheries Act. This is a nationally standardized environmental effects program for Canadian pulp mills; monitoring efforts will include: plume dispersion modeling, effluent characterization, habitat mapping; and sediment, benthic invertebrate and fish sampling. The first cycle report is due April 1, 1996 (McDonald, 1993).

Major sawmills that employ 200 to 700 people are located at Canal Flats, Cranbrook, Elko, Bonners Ferry and Libby. An abandoned post and pole treatment plant at the Libby mill site has been declared a Superfund site and remedial action plans are being prepared (Fox, 1993).

Municipal Wastes

Discharges from municipal (domestic) waste treatment facilities can increase suspended solids, biochemical oxygen demand (BOD) and nutrient levels in receiving streams even after conventional secondary treatment. Instream concentrations of ammonia can become elevated, causing toxicity to trout and other aquatic life, if receiving stream dilution capacity becomes insufficient during low-flow periods. However, the toxic (unionized) form of ammonia is pH-dependent and usually is microbically oxidized to nitrate fairly rapidly in surface waters.

Major municipalities in the Kootenay Basin served by secondary waste treatment facilities are listed in Table 1. The rest of the basin's population uses septic tanks or smaller community systems. Information in Table 2 suggests that water quality effects, like increased BOD and ammonia toxicity should not occur downstream from the Libby, Bonners Ferry and Troy facilities because of the dilution provided by the Kootenay River; e.g., minimum flow requirements during regulated releases from Libby Dam. Facilities with the highest potential to affect receiving streams are those serving the cities of Creston (Goat River), Eureka (Tobacco River) and Kimberley (St. Mary River), where receiving stream-to-effluent ratios can be as low as 30:1 to 70:1 during low flow periods. Monitoring efforts in the Kootenay Basin intended to determine potential effects of domestic wastes should focus on these facilities/receiving streams.

Some lakes within the basin may also be affected by domestic wastes. Septic tank drainage from settlements around Wasa, Tie and Rosen lakes are believed to affect water quality (Rocchini et al., 1976 B). Many other small lakes within the basin with low flushing rates and heavy cottage or cabin development may also be affected (McDonald, 1993).

Highways and Railroads

Highway and railroad construction has eliminated important fish habitat by shortening and straightening the channels of streams and rivers. These channel manipulations cause increased water velocities, which lead to more channel and

Table 2
Communities in the Kootenay River Basin served by secondary waste treatment facilities

Community	Estimated Population	Estimated Discharge (cfs)	Receiving Stream	Measured (or estimated) low flow (cfs)
Cranbrook	18,000	0	None*	-
Kimberley	7,000	2.0	St. Mary R.	143
Fernie	6,000	1.7	Elk R.**	310
Creston	5,000	1.5	Goat R.	41
Sparwood	4,000	1.2	Elk R.	161
Elkford	3,000	0.8	Elk R.**	(80)
Libby	3,000	0.8	Kootenay R.	4000
Bonners Ferry	2,000	0.6	Kootenay R.	6000
Troy	1,000	0.3	Kootenay R.	5000
Eureka	1,000	0.3	Tobacco R.	(15)

* The City of Cranbrook has not discharged its domestic wastes to surface waters since 1977 when land disposal with spray irrigation was commenced.

** discharges to infiltration lagoons near the river

streambank erosion and higher suspended solids concentrations in the water column. In many places riprap has replaced or removed important fish habitat like undercut banks or overhanging vegetation. The rerouting of the Great Northern Railroad in the late 1960s shortened the length of the Fisher River, Wolf Creek and Fortine Creek by over two miles (USACE, 1971). On portions of Swamp Creek east of Libby fish habitat provided by channel meanders has been replaced with a straightened, riprapped channel along Highway 2 (OEA, 1992). Little, if any, additional documentation exists regarding impacts to stream channel and fish habitat caused by highways and railroads in the Kootenay Basin.

Agriculture

Potential water quality effects caused by agriculture include grazing within riparian areas, dewatering of streams for irrigation, and runoff from livestock feedlots, croplands, orchards and heavily grazed pastures. This runoff can contain nutrients or herbicides and pesticides. Basin-wide, these impacts are minimal given the relatively small amount of agricultural land above Kootenay Lake. In a specific, localized area, however, they may be more significant.

Nutrient pollution from agriculture appears to be minimal both basin-wide and locally. Total phosphorus contributions to the Kootenay River from all sources in British Columbia above Lake Koocanusa were estimated to be less than 5000 pounds per year (Rocchini et al., 1976 B), which was about 0.03% of the amount contributed by Cominco's fertilizer plant in the early 1970s. Some localized dewatering of small tributary streams likely occurs in the Tobacco River watershed, the Deep Creek watershed (south of Bonners Ferry) and near the mouths of small streams draining the southwestern Purcell Mountains between Bonners Ferry and Creston. Grazing by cattle is extensive in the Fisher River watershed. Very little pesticide or herbicide monitoring has occurred anywhere in the basin, even in the above, most-concentrated agricultural areas. In areas where these toxicants have likely been most heavily applied; i.e., croplands or orchards between Bonners Ferry and Creston–their concentrations in surface and groundwater should be determined.

Subbasin Descriptions

To properly manage and conserve the water quality and other aquatic resources of the Kootenay River Basin, it is important to emphasize watershed, rather than political, boundaries. This approach will require thoughtful cooperation and communication between agencies and other interested entities, but it is the best way to manage and sustain these resources over the long-term. The widespread influence of Libby Dam and Reservoir upon the Kootenay River serves as basis for the delineation of three rather distinct subbasins (Figure 11). Future water quality and aquatic resource management and planning should focus upon these subbasin delineations rather than the more arbitrary political boundaries.

Subbasin 1, totally within British Columbia, is the portion of the basin upstream from Libby Reservoir at full-pool. Major tributaries include the Vermillion, Cross, Palliser, Lussier, White, St. Mary and Bull rivers. This subbasin has a drainage area of approximately 15,700 km^2 (6060 mi^2), which amounts to roughly 43% of the basin upstream of Kootenay Lake.

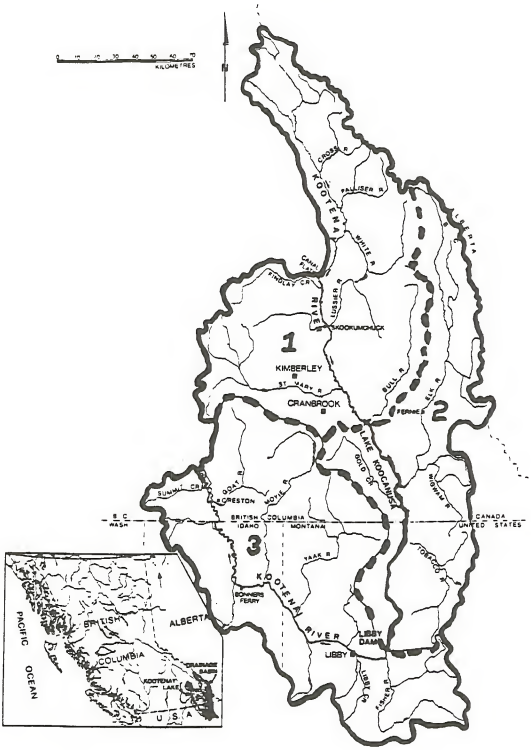
Subbasin 2, within British Columbia and Montana, contains all the watersheds draining directly into Libby Reservoir at full-pool, including the Elk and Tobacco rivers and Gold Creek. This subbasin 2 has a drainage area of 9750 km^2 (3110 mi^2), or approximately 27% of the basin.

Subbasin 3, within Idaho, Montana and British Columbia, is the portion of the basin downstream from Libby Dam. Major tributaries include the Fisher, Yaak, Moyie and Goat rivers. This subbasin 3 has a drainage area of 10,850 km^2 (4190 mi^2), or approximately 30% of the basin.

Subbasin 1

The average annual discharge of the Kootenay River ranges from 175 cfs at Kootenay Crossing, 3050 cfs at Canal Flats and about 9000 cfs just above Lake Koocanusa. The most

Figure 11
Kootenay River subbasins



populated portion of Subbasin 1 is the St. Mary River watershed. Most of the remaining population is scattered among small villages, settlements and rural home sites along the Kootenay River corridor from Canal Flats to the confluence of the Bull River. All watersheds draining the Continental Divide, an area encompassing about two-thirds of this subbasin, are largely uninhabited. Settlements are also largely absent in the Findlay and Skookumchuck watersheds, which comprise about 15% of this subbasin. Logging and road building are the only development activities in this large, contiguous block of Subbasin 1.

Primary point sources of pollution are the Cominco mine and the Kimberley municipal waste treatment facility in the St. Mary watershed, and Crestbrook's pulp mill on the Kootenay River about 40 km upstream from the confluence of the St. Mary River. Given the relatively high population density and degree of historic and on-going development activity, the St. Mary River watershed should have the highest priority for continued water quality monitoring. Monitoring programs designed to evaluate the effects of logging and road building should also be initiated. A fisheries inventory in the mid 1970s found spawning and rearing potential to be low to poor in tributaries of the White River, although these habitat parameters were rated fair to excellent in the main forks of this river. Overall, the White River system appeared to have a quite high fisheries potential, but "comparatively few fish were taken relative to the time spent sampling" (Gunville, 1977). Low, very low or non-existent densities of native cutthroat trout were found in tributaries of the White and Bull rivers during random, "spot checks" in the mid 1980s (Artech, 1986). Sediment and fisheries monitoring need to be conducted in at least the White and Bull rivers, if not others, to determine if this less than optimal fisheries condition has been caused or aggravated by logging and road building; or if it is attributable to other habitat or water quality factors such as naturally low concentrations of dissolved nutrients. The Vermillion River, which is entirely within Kootenay and Mt. Assiniboine National and Provincial Parks should also be monitored to determine fisheries and sediment delivery conditions in an undeveloped (or control) watershed.

Subbasin 2

The most populated portion of this subbasin is the coal field region in the lower half of the Elk River watershed. The only other albeit much less populated area is along the Tobacco River. Primary point sources of pollution are discharges from settling ponds at five major coal mines and the effluent from the Sparwood municipal waste treatment plant in the Elk River watershed; and, in the Tobacco River watershed, the city of Eureka's municipal waste discharge.

Despite the relatively high degree of development in the Elk River Basin, the fishery resource remains one of the best in the Kootenay Basin, especially for native westslope cutthroat trout. Creel surveys conducted in 1991 (Westover, 1993) demonstrated that angler use and average length of cutthroats had increased since 1982, although likely just in response to changes in fishing regulations. It is important to continue water quality and fishery monitoring in the Elk watershed because of projected increases in coal production and human population growth. However, a priority watershed for greatly increased monitoring is the Wigwam River. This stream enters the Elk River below the mainstem river dam at Elko, and is therefore the only part of the Elk River watershed available for spawning use by adfluvial fish from Lake Koocanusa. Oliver (1979) demonstrated that the Wigwam is the most important spawning tributary for reservoir and river-dwelling bull trout in Subbasin 2, if not the entire Kootenay Basin. This researcher collected and tagged 515 migrating adults during fish trapping efforts from July through October 1978. He also noted that forest fires and substantial amounts of logging and road building had occurred, and was continuing to occur, in this watershed and that "high silt loads are characteristic."

The Wigwam River is an international watershed with part of its headwaters in Montana. The Montana portion is mostly within the 34,000-acre Ten Lakes Wilderness Study Area, but some logging and road building has occurred along Wolverine, Bluebird and Rich creeks. The Wigwam watershed offers an opportunity for joint provincial/state studies and management to protect a potentially threatened or endangered species.

Subbasin 3

The average annual discharge of the Kootenay River ranges from approximately 12,000 cfs at Libby to 17,000 cfs at its confluence with Kootenay Lake. The most significant present or potential pollution sources are the ASARCO settling ponds along Lake Creek, exploration and possible development activities by Noranda in the Libby Creek watershed, the city of Creston's waste treatment facility, abandoned hard rock mines, and logging and road building.

Three watershed areas are of highest priority regarding water quality and fisheries monitoring: the Libby/Lake Creek area; the Moyie and Yaak rivers; and the Fisher River.

The effects of past and potential hard rock mining in the Libby/Lake creek area needs to be better evaluated. In Libby Creek, Noranda's pre-development water quality monitoring should be expanded to include the sampling of all abandoned mine discharges along with an evaluation of their reclamation potential. Additional monitoring stations and increased sampling frequency for select heavy metals, nutrients and possibly suspended sediments should be conducted on Lake Creek to better document the post-development phase of the ASARCO tailings impoundment.

The Yaak and Moyie rivers are both international watersheds with portions of each in British Columbia, Idaho and Montana. Cutthroat trout densities in the BC portion of the Moyie were rated as dense to very dense (Artech, 1986); the Idaho portion is considered a very important recreational fishery (FERC, 1991). Primary forks and tributaries of the Yaak River contain a substantial resident fishery (Marotz et al., 1988). The highly regarded fishery resource values of these rivers, along with their adjoining geographic location, presents a unique opportunity for cooperative monitoring and management among three state/provincial governments and two national forests. Since logging and road building are the only significant development activities in the Yaak/Moyie, sediment, fisheries and cumulative impact studies should be conducted with political boundaries hopefully not becoming barriers to cooperative efforts.

The Fisher River watershed is predominantly owned by private timber companies. Most of the watershed has recently

been burned by forest fires or logged and roaded without the management constraints that are applicable on National Forest lands. Cattle grazing also occurs throughout the watershed and soils are moderate to highly erodible (Marotz et al., 1988). Comprehensive evaluations of the effects of sediment upon water quality and fisheries need to be initiated in this intensely developed watershed.

The three most important bull trout spawning streams in Subbasin 3 are Quartz, Pipe and O'Brien creeks which originate in the Purcell Mountains and enter the Kootenay River between Libby and Troy (Skaar, 1993). Development activities in these small watersheds should be managed to prevent increased sediment delivery to these streams.

Prioritization of Water Quality Issues

The following is a synopsis of major water quality and fisheries issues and concerns in the Kootenay River Basin, listed in order of priority for monitoring or other action.

Libby Dam

The presence and operation of this facility continues to impact the growth or reproduction of white sturgeon and bull trout, which are both being proposed for listing as threatened or endangered species, as well as Kootenay Lake's native kokanee fishery and the upper river's native westslope cutthroat trout population. Changes in water release patterns at the dam that would be beneficial for the white sturgeon and kokanee; e.g., higher rates of discharge during spring and early summer, could in turn cause reductions in electrical generation capabilities later in the year or reduce the likelihood that the reservoir will reach full-pool during summer. This is a contentious situation, involving recreational users of Lake Koocanusa versus Kootenay Lake, energy needs versus the needs of endangered species, hatchery supplementation versus natural reproduction of white sturgeon; and whether dam mitigation has been adequate to perpetuate native cutthroat and bull trout populations. The KRN could propose to mediate the concerns being expressed by these varied interests, in hopes of finding some common ground.

Logging and Road Building

This is the most widespread, but least understood, problem in the basin. Watersheds with the highest priority for sediment and fisheries monitoring are: the White/Bull rivers in Subbasin 1; the Wigwam River in Subbasin 2; and the Yaak/Moyie and Fisher rivers as well as Boundary Creek in Subbasin 3. In turn, tributary streams within these watersheds with the highest priority for monitoring should be those with steep slopes, erodible soils and past or present spawning by cutthroat or bull

trout. The KRN should be instrumental in coordinating international, cooperative monitoring and management efforts in at least the Yaak/Moyie and Wigwam River watersheds; or on a smaller scale, within the Boundary Creek watershed.

Organochlorine Contamination

The presence of dioxins and furans in sport fish collected from the Kootenay River and Lake Koocanusa, and the finding that aquatic organisms are bioconcentrating these toxins, is the most significant contamination problem presently attributable to a point source of pollution in the Kootenay Basin. The waste treatment improvements being installed at the Skookumchuck pulp mill should reduce the levels of this contamination. The rather extensive environmental effects monitoring being conducted in Canada by Crestbrook Forest Industries should be duplicated by U.S. water quality agencies at stations in Lake Koocanusa and downstream of Libby Dam.

Hard Rock Mining

All abandoned mines in the basin need to be located, and site-specific evaluations conducted, to determine the severity of their water quality effects. Funding should then be sought for reclamation of problem sites. Monitoring of heavy metal concentrations in the St. Mary River above and below Cominco's mine should be continued. Additional water quality monitoring on Lake, Stanley and Libby creeks should be initiated to determine sources and trends in heavy metal concentrations. Fish tissue analyses should be conducted to determine concentrations of cadmium, lead and mercury, which are metals known to bioaccumulate in aquatic organisms and/or biomagnify through food chains.

Coal Mining

The westslope cutthroat and bull trout populations in the Elk River presently appear to be in good condition. However, sediment and fisheries monitoring needs to continue, particularly if coal mining continues to increase in the basin. Evaluations need to be focused on tributaries used for spawning near the coal mines.

Herbicides and Pesticides

An inventory of herbicides and pesticides being used in the Kootenay Basin, and where they are most heavily used, needs

to be conducted. Surface and groundwater monitoring should then be undertaken near or within areas of heaviest application rates to determine if drinking water criteria are being exceeded.

Municipal Wastes

As an initial step, monitoring of unionized ammonia should be conducted in receiving streams downstream from the cities of Creston, Eureka and Kimberley during summer, low-flow conditions. If human population growth continues in the Elk River watershed, similar evaluations will also become necessary particularly downstream of the Sparwood wastewater treatment plant.

Highways and Railroads

An inventory of "lost" fisheries habitat and chronic suspended solids concentrations caused by existing highways and railroads should be compiled. When new construction or reconstruction is proposed, mitigation; i.e., reactivation of severed meanders or oxbows and/or construction of new, meandering channel sections should be strongly considered.

Recommendations

During the past 2½ years, the quarterly meetings of the Kootenay River Network (KRN) have provided an invaluable format for information exchange and discussions among agencies and citizens regarding water quality and other aquatic resource issues. As a result of these meetings, participants have become more aware of concerns and issues as well as past and present scientific evaluations within and outside of their varied geographic and political perspectives. An important function of the KRN should be to continue and expand upon this exchange of technical information. Rather than informal discussions about these evaluations/activities, as has occurred at past meetings, this communication should become more formalized. Agencies should be requested to provide brief, written activity summaries to the KRN on a quarterly, or at least yearly, basis. These summaries could be compiled and updated by a facilitator/coordinator prior to every meeting. With less time devoted to information exchange, more meeting time would be available to explore a specific issue or topic. In fact, meetings could largely be dedicated to a specific theme centered around any of the various issues discussed in this report. For example, the KRN could sponsor workshops, forums or detailed discussions about pulp and paper mill waste treatment technologies and their application in the Kootenay versus the Clark Fork River Basins; differences among basin water quality standards; how silvicultural BMPs, or indeed how timber harvest quotas, are applied or established within the various political jurisdictions; past, present and proposed mining activities in the basin; or on any or all of the numerous issues and potential conflicts surrounding the operation of Libby Dam. Forums or workshops could also be conducted on specific issues within specific watersheds; i.e., past and ongoing logging activities in relation to aquatic resource monitoring within international watersheds like the Yaak and Moyie rivers or Boundary Creek.

The establishment of theme-oriented meetings, which should be well advertised and open to the public, would expand the function of the KRN into public outreach, awareness and education. In order to ensure balanced presentations at these events, interested or affected agency, industry and citizen panelists would need to participate.

The KRN could also become a clearing house for public input opportunities. Notices of forthcoming government meetings or public hearings on water quality and other aquatic resource issues, along with a summary of the issue(s) involved, could be included in the quarterly technical activities summary prepared by the facilitator.

A final coordination function for the KRN should be to encourage or sponsor meetings or workshops among federal, provincial, tribal and state agencies that have similar management or monitoring responsibilities. The focus of these meetings could again range from discussions about a single watershed to basin-wide topics. For example, regarding fisheries management agencies, a watershed-specific meeting could be set up between biologists from the Montana Department of Fish, Wildlife and Parks' Libby office and the Cranbrook BC Ministry of the Environment, Fisheries Branch to discuss bull trout monitoring or management in the Wigwam River watershed. Basin-wide meetings involving the aforementioned agencies, plus biologists from the Idaho Fish and Game, U.S. Fish and Wildlife Service, Kootenai Tribe of Idaho and Environment Canada, could address the status of endangered species, standardization of sampling techniques, growth and reproduction data for various fish species, the success or failure of harvest regulations, hatchery operations, etc.

However, a meeting or series of meetings among agencies responsible for water quality monitoring should be the highest priority. Agencies invited should include the U.S. Army Corps of Engineers, BC Ministry of Environment, Montana Department of Health and Environmental Sciences, Idaho Department of Health and Welfare, Environment Canada, Kootenai Tribe of Idaho, U.S. Geological Survey, U.S. Forest Service and U.S. Environmental Protection Agency. Crestbrook Forest Industries should also be asked to participate because of their ongoing environmental effects monitoring program on the Kootenay River. The meeting(s) should address the specifics of past, present and proposed

monitoring efforts on the river and its major tributaries. The initial and most important focus should be to determine if agency funding and interest exists to continue and possibly expand water quality monitoring on the Kootenay River at four stations that seem essential to determine future water quality trends: above Skookumchuck (at or near Canal Flats); below the St. Mary River (at or near Wardner); below Libby dam; and at the mouth of the river near Creston. The above stations, particularly the latter three, have fairly good long-term monitoring records for heavy metals and nutrients. They have recently been, or are presently being, monitored at some level by the BC Ministry of the Environment, U.S. Army Corps of Engineers, Crestbrook Forest Industries or the U.S. Geological Survey. Coordination regarding parameters being measured as well as sampling frequencies and periods seems essential.

Other topics at the water quality monitoring meeting(s) could include how U.S. agencies can set up monitoring programs to complement the pulp mill effluent studies being conducted on the river in Canada; joint U.S./Canadian herbicide and pesticide monitoring in the Bonners Ferry-to-Creston area; and exchange of site-specific water quality data on streams that have or could be affected by acid-mine drainage.

The above functions are realistic, short- to mid-term activities or objectives for the KRN to pursue. To carry out these important functions, the immediate priority of the KRN must be to fund a part-time facilitator/information specialist/fundraiser. Without such a multi-skilled person, it will be very difficult for the KRN to accomplish any of the communication and education efforts that are vitally needed across the boundaries of the Kootenay River Basin. Funding for this position will have to come from agency budgets, industry contributions, and/or environmental or other foundations. Tapping into the latter sources will require that the KRN incorporate as a non-profit organization, possibly in both the U.S. and Canada. If foundation sources are pursued, an invaluable, up-to-date guidance document would be:

Environmental Grantmaking Foundations
published by:
The Environmental Data Research Institute
1655 Elmwood Drive, Suite 225
Rochester, New York 14620-3426

The cost of this publication is $60 (U.S.), including shipping and handling. Funding for the workshops, forums and meetings discussed earlier could also conceivably be sought from foundations listed in this manual.

Accomplishing the above functions and tasks will not necessarily be easy. The Kootenay River Basin probably has the greatest diversity of political entities, on a per-square-mile basis, of any watershed in North America. It is distant from the provincial and state capitals of Vancouver, Boise and Helena, let alone Ottawa and Washington, D.C. If progress is to be made regarding any of the issues described or efforts proposed in this report, a certain degree of commitment will be required by those who best know and care about the river, its tributaries and watershed. Indeed, the major challenge, yet opportunity, facing the KRN is to ensure that political boundaries do not become barriers, and that communication and education among international, provincial, tribal, state, industry and public interest entities be enhanced to achieve the common benefits derived from maintaining and enhancing the chemical, physical and biological integrity of the Kootenay River Basin.

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